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Emotion Recognition in Children with Down Syndrome:

Influence of Emotion Label and Expression Intensity

Katie R. Cebula, Jennifer G. Wishart, Diane S. Willis, & Tom K. Pitcairn

Corresponding author:

Katie R. Cebula, PhD

Email address: Katie.Cebula@ed.ac.uk

University of Edinburgh

School of Education

Holyrood Road

Edinburgh, EH8 8AQ, UK

Running Head: EMOTION RECOGNITION AND DOWN SYNDROME

Abstract

Some children with Down syndrome may experience difficulties in recognising facial emotions, particularly fear, but it is not clear why, nor how such skills can best be facilitated. Using a photo-matching task, emotion recognition was tested in children with Down syndrome, children with non-specific intellectual disabilities and cognitively-matched typically-developing children (all groups $N = 21$) under four conditions: veridical vs exaggerated emotions and emotion-labelling vs generic task instructions. In all groups, exaggerating emotions facilitated recognition accuracy and speed, with emotion labelling facilitating recognition accuracy. Overall accuracy and speed did not differ in the children with Down syndrome, although recognition of fear was poorer than in the typically developing children and unrelated to emotion label use. Implications for interventions are considered.

Keywords: Down syndrome, emotion recognition, emotion labelling.

Abbreviations: BPVS: British Picture Vocabulary Scale; CA: chronological age; MA: mental age; PMA: performance mental age; VMA: verbal mental age; WISC: Wechsler Intelligence Scales for Children; WPPSI-R: Wechsler Preschool and Primary Scales of Intelligence, revised.

Emotion Recognition in Children with Down Syndrome: Influence of Emotion Label and Expression Intensity

Within intellectual disability research, emotion recognition is an area that has received much attention. This is perhaps unsurprising, as it is a core skill in social interaction, long recognised as underpinning many other areas of learning (e.g. Rogoff, 1990). Much of this work has focused on autism spectrum conditions, but in recent years emotion recognition research has been informed by a behavioural phenotype approach, exploring and contrasting patterns of strengths and difficulties across a range of specific aetiologies (e.g. Porter, Coltheart & Langdon, 2007; Whittington & Holland, 2011). Such an approach, if combined with a developmental perspective, has the potential to inform the design of early and specifically targeted interventions (Fidler & Nadel, 2007). Yet in order to maximise intervention utility it is important to establish precisely which aspects of emotion recognition present difficulties for children with specific aetiologies, and which specific techniques will best facilitate emotion recognition. The present study explored these issues in relation to children with Down syndrome.

A number of studies conducted to date have shown that children and adults with Down syndrome are significantly less proficient in the understanding of emotions than would be expected on the basis of chronological age, and have also indicated difficulties in comparison to typically developing individuals of similar developmental levels (Hippolyte, Barisnikov, Van der Linden & Detraux, 2009; Kasari, Freeman & Hughes, 2001; Pochon & Declercq, 2014; Virji-Babul, Watt, Nathoo & Johnson, 2012; Way & Rojahn, 2012; Williams, Wishart, Pitcairn & Willis, 2005; Wishart & Pitcairn, 2000, but see Celani, Battacchi & Arcidiacono, 1999; Channell, Connors & Barth, 2014; Pochon & Declercq, 2013 for exceptions). A number of these studies explored six basic emotions (happiness, sadness, anger, surprise, fear, disgust), and several reported difficulties in relation to specific

expressions, often that of fear (Kasari et al., 2001; Virji-Babul et al., 2012; Williams et al., 2005; Wishart & Pitcairn, 2000); error patterns with respect to fear recognition were also found to be developmentally atypical (Williams et al., 2005). Fear recognition difficulties have not always been found in all emotional understanding tasks, nor have they always been shown to be syndrome-specific (see Cebula & Wishart, 2008 for review). Difficulties with other emotions have also been reported, albeit less consistently (e.g. Wishart & Pitcairn, 2000; Kasari, et al., 2001). Taken together though, the findings of these studies do suggest that emotion recognition in general, and fear recognition in particular, may be an area of concern with some children with Down syndrome.

A variety of methods have already been developed to support children with developmental disabilities in their understanding of emotions (e.g. Baron-Cohen, Golan, Wheelwright & Hill, 2004; Golan et al., 2010). However, children with Down syndrome may show a different profile of emotional understanding skills from that found in other developmental disabilities (e.g. Celani et al., 1999), and there may also be differences in the origin of any difficulties. To develop targeted interventions, it is therefore important to establish in more detail which specific components of emotion recognition are problematic for children with Down syndrome.

One difficulty here is that emotion recognition tasks tend to conflate semantic knowledge of emotion labels with perceptual face processing ability (Lindquist & Gendron, 2013; Vicari, Reilly, Pasqualetti, Vizzotto & Caltagirone, 2000), often using emotion labels in verbal task instructions (happy, sad, etc.), in combination with facial expressions of emotion (e.g. photographs, schematic drawings). As a result it is sometimes unclear whether the verbal emotion labels, the facial stimuli, or both are problematic for study participants.

Language plays a central role in the understanding of emotions (Lindquist & Gendron, 2013; Reed & Steed, 2015), and in typical development emotion labels are used

from early childhood (Lindquist & Gendron, 2013; Ridgeway, Waters & Kuczaj, 1985). Some labels, such as happy, sad and angry are used accurately earlier than others, such as fear and disgust (Székely et al., 2011; Vicari et al., 2000; Widen & Russell, 2003), but accurate use of emotion labels continues to develop throughout the school years (Widen & Russell, 2008; Vicari et al., 2000).

It is possible that the emotion recognition difficulty found in children with Down syndrome relates specifically to difficulties with the emotion labels used in tasks. Indeed, there is some recent evidence of this: in comparison to younger MA-matched typically developing children, Pochon and Declerq (2013, 2014) have reported difficulties amongst children with Down syndrome in an emotion recognition task employing emotion labels, but no significant difficulties in an emotion vocalisation-to-face matching task which did not use emotion labels. They concluded that children with Down syndrome may have a specific emotional lexicon deficit, rather than a difficulty in recognising emotional expressions per se, although it is unclear whether this was the case across all of the emotions they studied. Such a difficulty would, though, fit with evidence noted by Kasari et al. (2001) that children with Down syndrome are exposed to less conversation about emotional terminology than are typically developing children (Tingley, Gleason, & Hooshyar, 1994); in particular, Kasari et al. suggested that, because young children with Down syndrome are often perceived to be of a friendly and happy disposition, caregivers may use fewer negative emotion words with them, providing children with fewer opportunities to learn these particular emotion labels.

Rather than difficulties with linguistic emotion labels, distinguishing and decoding the facial emotion stimuli themselves may be problematic for individuals with Down syndrome. This possibility is supported by the finding that emotion recognition difficulties have been reported even in tasks that have been designed to minimise language demands (e.g. Williams et al., 2005). It is also supported by findings of differences in the emotional expressions

experienced in interactions between parents and their children with Down syndrome from early in life (e.g. Carvajal & Iglesias, 1997).

One way in which the influence of the facial emotions themselves can be explored is to manipulate the intensity of expressions in tasks, and assess whether recognition improves with increased intensity. Most of the studies to date that have explored the effects of emotion intensity on facial expression recognition have been with typically developing participants (Calder, Young, Rowland & Perrett, 1997; Gao & Maurer, 2009; Herba, Landau, Russell, Ecker & Phillips., 2006). These have often used computer-manipulated facial expressions of emotion and results generally show that more intense or exaggerated facial expressions of emotion are recognised more quickly, and with equivalent or increased accuracy, than less intense expressions. However, the size of this effect can vary with emotion (Herba et al, 2006). Exaggerated emotions might result in more accurate recognition because fine detail is more easily detected (Calder et al., 1997; Guo & Maurer, 2009), and may attract greater attentional resources (Kumfor et al., 2011). Increased intensity of emotion has also been shown to lead to increased neural response. For example, Morris et al. (1996, 1998) found that increased intensity of fearful expressions led to heightened amygdala response in typically developing participants. Although there has been some work with atypical child populations using computer manipulated facial emotion stimuli (e.g. Blair, Colledge, Murray & Mitchell, 2001; Castelli, 2005), the effects of intensity manipulation have not previously been examined in children with Down syndrome.

These two components of emotion recognition - perceptual (facial expression recognition) and linguistic (emotion label understanding) - may be closely related, but follow very different developmental pathways (Vicari et al., 2000). While it is unlikely to be possible to disentangle them completely, a better understanding of how these two elements

contribute towards any difficulties experienced by children with Down syndrome might begin to pave the way for the development of targeted interventions.

The present study explored emotion recognition in children with Down syndrome, in comparison to children with non-specific intellectual disabilities and typically developing children matched for developmental age. It aimed to establish:

- the extent to which exaggeration of facial expressions and the use of emotion labels effect emotion recognition accuracy and speed
- whether any differences exist across groups in ability to recognise specific emotions and, if so, whether these difficulties are predominantly perceptual or linguistic.

It was hypothesised that exaggerated emotions and emotion labels would improve the overall accuracy and speed of emotion recognition in all three groups of children, but not necessarily equally. In line with previous research it was hypothesised that children with Down syndrome would experience particular difficulties in fear recognition, although the literature to date does not allow for a clear prediction on whether such a difficulty would be predominantly perceptual or linguistic.

Method

Participants

Eighty-one children participated in the study: 28 with Down syndrome (10 male, 18 female; 9;03 – 18;09 years), 25 with non-specific intellectual disabilities (11 male, 14 female; 9;01 – 17;05 years) and 28 typically developing children (14 male, 14 female; 3;04 – 6;06 years). Children participated from 6 mainstream schools, 4 special schools and 1 mainstream nursery. The majority of children with intellectual disabilities were in special school placements, reflecting educational placement patterns in the region in which the study was carried out.

Parents were sent letters about the study and consent forms. These went to families already on a database of voluntary study participants held by the research team, and also via local mainstream and special schools where the head teachers identified pupils who met the inclusion criteria. Response rates were high, but because researchers were not always informed of the number of letters sent by the school, precise response rates cannot be reported.

Diagnosis of the children in the Down syndrome and non-specific intellectual disability groups was confirmed by cross-checking local educational and central health records. The non-specific intellectual disability group was composed of children for whom etiology of intellectual disabilities was unknown. Children with identified genetic syndromes, a family history of intellectual disabilities or with known neurological insult were excluded. In addition, children were excluded from all three participant groups if they had attention deficit hyperactivity disorder, severe sensory or physical impairment, severe behavioral difficulties, or were on the autism spectrum. In the case of the two intellectual disability groups an additional exclusion criterion was profound or complex intellectual disabilities as task demands were likely to be beyond the capabilities of these children.

Design and Procedure

Assessment measures. Cognitive ability was assessed using a four-subtest short-form of the Wechsler Preschool and Primary Scales of Intelligence-Revised (WPPSI-R: Wechsler, 1990). This short-form consisted of two subtests from the original performance and verbal scales and has shown high reliability coefficients and high validity in terms of correlation with full test scores ($r_{tt} = .932$, $r = .914$: Sattler, 1992). Vocabulary comprehension was measured using the British Picture Vocabulary Scale (BPVS-II: Dunn, Dunn, Whetton, & Burley, 1997). Children were also administered the Benton Facial Recognition Test (Benton,

Sivan, Hamsher, Varney & Spreen, 1983). This is a standardized procedure for assessing the ability to identify unfamiliar human faces. Participants are presented with a single black and white photograph of a face and then instructed to locate that face in a display of six photographs, where it appeared either one or three times. The 27-item short-form of this test was used on which a score of 11 might be expected on the basis of chance alone (Benton, Sivan, Hamsher, & Spreen, 1994).

Emotion-matching task. This experimental task required participants to match photographs of unfamiliar adults on the basis of facial emotion. It used photographs from Ekman and Friesen's Facial Affect Slides (1976), a series of 11.5 x 17.5 cm black and white photographs of men and women expressing the six basic emotions (happiness, sadness, anger, surprise, fear and disgust) and a set of 'neutral' poses. These photographs have been used extensively in research with typical and atypical children and adults, and have high inter-rater agreement regarding the emotion displayed (Ekman & Friesen, 1976). Children were shown one facial photograph, and were then asked to point to a photograph of a different person showing the same emotion from a choice of three photographs (the correct emotion and two distracters) that were then uncovered underneath. The photographs were all mounted on a single piece of cardboard. The photographs selected from the Ekman and Friesen series for this task consisted of one male and one female face displaying each of the six basic emotions. Where the male model was shown in the initial photograph to be matched, the female model was shown in the three choice photographs and vice versa. Position of correct answer was counterbalanced across trials.

Two intensity levels of emotion were used in this task: 'veridical' and 'exaggerated'. The 'veridical' trials used the Ekman and Friesen faces. The 'exaggerated' trials used photos taken from the Facial Expressions of Emotion – Stimuli and Tests series (FEEST: Young, Perrett, Calder, Sprengelmeyer & Ekman, 2002). These were the same photographs as those

used for the ‘veridical’ trials, but digitally altered so that the emotional expressions appear exaggerated in comparison to the veridical Ekman and Friesen photographs. This digital alteration enhances the emotional intensity of the expression displayed (Calder et al., 2000). Various levels of exaggeration are available, but as this study was the first to utilise these images with children with Down syndrome, the largest degree of exaggeration (175%) was used to ensure that any effects were detectable. These exaggerated FEEST photographs are only available for one male and one female model from the Ekman and Friesen series. Therefore both the veridical and the exaggerated trials used photographs of only these models.

Altogether there were 48 trials – presented as 24 within each of two test sessions. Each set of 24 trials consisted of 12 presented as ‘veridical emotions’ and 12 ‘exaggerated emotions’. In each set of 12 trials each of the six basic emotions was presented as the target twice. Exactly the same 24 trials were used in each of the two test sessions. However, in one test session generic task instructions were used (the children were shown the target photo and asked: “Who feels the same as this person?”). In the other test session emotion labelling task instructions were used (the children were shown the target photo and told: “This person feels (e.g.) happy. Who feels the same as this person?”). These sessions were presented in counterbalanced order, and for each child, trial order was identical in each session. There were therefore four conditions in total: veridical emotions with generic task instructions; exaggerated emotions with generic task instructions; veridical emotions with emotion labelling task instructions; exaggerated emotions with emotion labelling task instructions.

In any trial all the photographs (i.e. the initial photograph and the three choice photographs) were either veridical or exaggerated. The emotions used in the distracter photographs were identical for each of the corresponding veridical and exaggerated trials, as was the position of the correct answer: the trials therefore only differed in one respect, the

intensity of the emotions depicted. The 24 ‘veridical’ and ‘exaggerated’ trials were presented in a fixed random order, with the constraints that: the first and last trials were the veridical happy expressions (in the case of the first trial, to ensure that the child could easily understand the task, and in the case of the last trial to ensure that they ended the session with a positive rather than negative emotion); the same emotion was never presented twice in a row; no more than two trials in a row depicted the same level of intensity (100 or 175%) or the same gender in the target photograph. The order of trials was therefore fixed, but half of the children in each group were presented with them in reverse order in case fatigue caused less accurate responding in later trials.

At the beginning of each test session children were asked to place their hands on a horizontal red line on the table, and reminded to return their hands to this position at the beginning of each trial (this was so that response time could be measured as accurately as possible). To avoid confounding expressive language and memory difficulties with any emotion-specific deficits, children were required to indicate their answer only by pointing, and all four photographs remained on the table to ensure that emotion recognition rather than recognition memory was being tested. Children were presented with the task by one experimenter and responses recorded by another experimenter who sat unobtrusively in the corner of the room. As recommended by Herba and Phillips (2004) and De Sonneville et al. (2002) response speed data were collected in addition to accuracy data, and all sessions were filmed for later analysis of response times.

Emotion label production. this task was presented around one week after the final emotion-matching task session, and it again used photographs from the Ekman and Friesen series. Children were shown a photograph from this series of a woman showing a neutral expression and told “This is Mary”. They were then shown a photograph of the same woman with a happy expression and asked “And now she feels...?” The children were then shown

photographs of the same woman displaying sadness, anger, surprise, fear and disgust, in a random order, and for each one, the same question repeated. There was one stimuli photo per emotion. This was a free-choice response task: no list of possible responses was provided. If children did not provide a response a prompt, 'Mary feels...?' was provided. Children's responses were noted, but incorrect responses were not corrected. The model chosen from the Ekman series was the one which Ekman and Friesen's data showed to have produced the highest average level of viewer agreement on the intended emotions, with agreement level for any single emotion not less than 88%.

Matching procedures. Following previous studies in this field, groups were matched on the basis of MA. From the original participant pool of 81, it was possible to MA-match 21 children from each participant group on the basis of their Wechsler scores. Each child from the non-specific intellectual disability and the typically developing groups was individually pair-wise matched as closely as possible to a child from the Down syndrome group (with no MA difference between individual children greater than 10 months and across all individually paired children a mean difference in MA of 4.3 months). Table 1 gives a summary of characteristics in the three groups. Mean MA (a composite of performance mental age (PMA) and verbal mental age (VMA)) did not significantly differ across groups (around 4 years in all groups) and ranges were also similar. There were also no significant group differences in PMA, VMA, vocabulary comprehension or gender balance. There were significant differences in Benton scores and chronological age. Although there were no differences between the two intellectual disability groups in terms of Benton scores, the non-specific intellectual disability group did obtain significantly higher scores than the typically developing group (Posthoc Scheffe $p < .05$). In addition, the Down syndrome and non-specific intellectual disability group did not differ in chronological age but, as would be expected, both groups were significantly older than the developmentally matched typically

developing group (Posthoc Scheffe $p < .001$). The age range in the typically developing group was also much smaller than in the other two groups.

- Table 1 about here -

Procedure. Ethical consent was obtained from the lead author's University ethics committee, and participants were only included once school and parental permission had been granted. Parents were provided with an information sheet and consent form, and were also asked to explain the study to their child, using child-friendly information and consent sheets where they judged these to be appropriate. Child assent was reconfirmed at each testing session, either verbally or using pictorial methods. Children were tested in a quiet room in their school, over a number of sessions. Length and number of sessions varied, depending on the child's availability and levels of fatigue, but children received some standardised and some experimental tasks in each session. The two photo-matching task sessions were always given at least one week apart.

Analysis. Accuracy data was manually recorded for each of the experimental tasks. In addition, response time for each emotion-matching trial was measured from the film clips of test sessions using the Observer Video-Pro, a software package which allows frame-by-frame analysis of events, and hence a high level of accuracy in data analysis (Noldus, Trienes, Hendriksen, Jansen, & Jansen, 2000). Coding of response time was conducted by the first author. For each trial, timing of response began when the card covering the three choice photographs was removed and stopped when the child's finger touched a photograph to indicate their answer. To assess inter-rater agreement of response time coding, twelve sessions from the full participant pool were re-coded by the third author. The mean kappa value was 0.95. The emotion production task was scored as follows: a score of one point was given for each emotion correctly identified (i.e. a maximum possible score of 6). The

following emotion terms were classed as correct: ‘happy’; ‘sad’; ‘angry’ or ‘cross’; ‘surprised’; ‘fearful’ or ‘scared’; ‘disgusted’ or ‘yuck’.

Results

Emotion-matching Task

This task required participants to match photographs of unfamiliar adults on the basis of facial expressions. Emotions were either veridical or exaggerated, and either labelled or non-labelled. Within each participant group total accuracy scores and mean response times did not differ as a function of either participant gender or order of presentation of conditions. Data were therefore collapsed in these respects.

Accuracy data. Table 2 shows the total accuracy scores for the three MA-matched groups, as well as these scores broken down according to condition.

- Table 2 about here -

Scores were analyzed using a 3 (participant group) x 2 (intensity condition) x 2 (labelling condition) mixed model ANOVA. This showed significant main effects of group ($F(2, 60) = 3.26, p < .05, \eta^2_p = .10$), of intensity ($F(1, 60) = 9.48, p < .01, \eta^2_p = .14$) and of labelling ($F(1, 60) = 18.79, p < .001, \eta^2_p = .24$), but no significant interaction effects amongst group, intensity and labelling.

Post-hoc analysis of the group effect showed that the typically developing children were more accurate overall on this task than the two intellectual disability groups, but that this difference was only significant in relation to the children with non-specific intellectual disabilities (Scheffe test $p < .05$). In relation to emotion intensity, children were significantly more accurate overall in emotion recognition when the stimuli were of greater intensity. In relation to emotion labelling, children were significantly more accurate overall in emotion recognition when the emotions were labelled (see above).

Response time data. Table 3 shows the total mean response time data for the three MA-matched groups, as well as these scores broken down according to condition.

- Table 3 about here -

Scores were analyzed using a 3 (participant group) x 2 (intensity condition) x 2 (labelling condition) mixed model ANOVA. This showed no significant main effect of group ($F(2, 57) = 1.90$, ns), nor of labelling ($F(1, 57) = 0.36$, ns), but a significant effect of intensity ($F(1, 57) = 33.91$, $p < .001$, $\eta^2_p = .37$). There were no significant interaction effects. The groups did not therefore significantly differ from each other in how quickly they gave an answer. Nor did the use of emotion labelling facilitate or impede speed of performance. However, on the whole the children were significantly faster at recognizing the exaggerated emotions compared to the veridical ones. To control for the possibility that some children may have been sacrificing accuracy for speed, the analysis was rerun, including only the response times for trials in which the children had responded correctly. The pattern of significant and non-significant results was unchanged.

Individual emotion accuracy data. Table 4 shows accuracy scores for the six individual emotions (conditions collapsed). To establish whether groups differed in their ability to recognize the six individual emotions, scores were analyzed using a 3 (participant group) x 6 (emotion) ANOVA. This showed significant main effects of group ($F(2, 60) = 3.26$, $p < .05$, $\eta^2_p = .10$) and emotion ($F(5, 300) = 44.85$, $p < .001$, $\eta^2_p = .43$) and a significant interaction between group and emotion ($F(10, 300) = 2.89$, $p < .01$, $\eta^2_p = .09$). When individual emotions were analyzed it was found that the Down's syndrome group were significantly less accurate than the typically developing group in the recognition of fear ($F(2, 60) = 4.02$; $p < .05$, $\eta^2_p = .12$; post-hoc Scheffe $p < .05$). In addition, the non-specific intellectual disability group were significantly less accurate than the typically developing group in the recognition of anger ($F(2, 60) = 5.74$, $p < .01$; post-hoc Scheffe $p < .01$).

- Table 4 about here -

To explore the effect of increased intensity and emotion labelling on recognition of these two emotions they were analyzed individually. As the differences in fear recognition ability lay between the Down syndrome and typically developing groups further analysis focused only on these two groups. This showed that the Down syndrome group was less accurate in fear recognition than the typically developing group when emotion labelling was used: $M(SD) = 2.05 (1.36)$ and $3.05 (1.16)$ for the Down syndrome and typically developing groups respectively, $t(40) = -2.56, p < .05$. They were also less accurate when emotion labelling was not used: $M(SD) = 1.67 (1.20)$ and $2.57 (1.29)$ for the Down syndrome and typically developing groups respectively, $t(40) = -2.36, p < .05$. The Down syndrome group were less accurate in fear recognition than the typically developing group when the exaggerated images were used: $M(SD) = 1.71 (1.23)$ and $2.86 (1.11)$ for the Down syndrome and typically developing groups respectively, $t(40) = -3.16, p < .01$. They were also less accurate with the veridical emotions, although the difference was non-significant: $M(SD) = 2.00 (1.38)$ and $2.76 (1.09)$ for the Down syndrome and typically developing groups respectively, $t(40) = -1.99, p = .054$.

Fear recognition scores in the Down syndrome group were in fact not significantly different from what would be expected on the basis of chance responding alone ($t(20) = 2.08, p = 0.051$). In terms of facilitation of fear recognition, paired t-tests showed that the Down syndrome group showed no significant improvement in fear recognition performance if labels were used ($t(20) = -1.56, NS$). Similarly, they showed no significant improvement in performance when exaggerated emotions were used ($t(20) = -1.06, NS$).

The difference in anger recognition between non-specific intellectual disability and typically developing groups was then explored. It was found that the non-specific intellectual disability group was less accurate than the typically developing group in anger recognition

when emotion labelling was used: $M(SD) = 1.57 (1.17)$ and $2.81 (1.47)$ for the non-specific intellectual disability and typically developing groups respectively, $t(40) = -3.02$, $p < .01$. They were also less accurate when emotion labelling was not used: $M(SD) = 1.19 (1.17)$ and $2.33 (1.46)$ for the non-specific intellectual disability and typically developing groups respectively, $t(40) = -2.80$, $p < .01$. The non-specific intellectual disability group were less accurate than the typically developing group when the exaggerated images were used: $M(SD) = 1.62 (1.16)$ and $2.62 (1.43)$ for the non-specific intellectual disability and typically developing groups respectively, $t(40) = -2.49$, $p < .05$. They also performed less accurately when the emotion was veridical: $M(SD) = 1.14 (1.11)$ and $2.52 (1.29)$ for the non-specific intellectual disability and typically developing groups respectively, $t(40) = -3.72$, $p < .01$.

Again, anger recognition scores in the non-specific intellectual disability group were not significantly different from what would be expected on the basis of chance responding alone ($t(20) = 0.21$, NS). In terms of facilitation of anger recognition, paired t-tests showed that the non-specific intellectual disability group showed no significant improvement in anger recognition performance if labels were used ($t(20) = -1.40$, NS). Similarly, they showed no significant improvement in performance when exaggerated emotions were used ($t(20) = -1.94$, NS).

Emotion Label Production Task

In this task children were asked to label each of the six emotions from photographs. The mean number of emotions correctly labeled were $3.45 (1.10)$, $2.95 (1.12)$ and $3.62 (1.07)$ for the Down syndrome, non-specific intellectual disability and typically developing groups respectively. Scores from this task were analyzed using a 3 (participant group) \times 6 (emotion) mixed model ANOVA. This showed no significant main effect of participant group ($F(2,60) = 2.09$, ns), a significant effect of emotion ($F(5, 300) = 63.12$, $p < .001$, $\eta^2_p = .51$) and no significant interaction ($F(10, 300) = 0.32$, ns). The groups did not therefore differ in their

overall ability to label the emotions, although some emotions were significantly more likely to be labelled correctly (happy was easier than all other emotions; sad was easier than all other emotions except for happy and angry; angry was easier than surprise, fear and disgust: $p \leq .001$ in all cases).

Relationships between assessment measures and experimental task performance

A series of correlations were carried out within each of the MA-matched groups using all available child data (Table 5). This showed that emotion-matching accuracy scores correlated significantly with mental age, verbal mental age and vocabulary comprehension levels in all three participant groups. A correlation between accuracy scores and chronological age was unique to the typically developing group. Accuracy scores correlated with performance mental age and with Benton test scores in the non-specific intellectual disability and Down syndrome groups. Emotion-matching accuracy scores did not correlate with emotion label production in any of the three groups.

- Table 5 about here –

Discussion

The present study explored the effect of exaggerated facial emotions and of emotion labelling on the speed and accuracy of emotion recognition in children with Down syndrome, children with non-specific intellectual disability, and typically developing children matched on cognitive ability. Across the participant groups as a whole, the children were more accurate in the recognition of emotions when they were more intense and when they were labelled, supporting previous findings with typically developing children (e.g. Herba et al., 2006; Russell & Widen, 2002). Children overall also recognized exaggerated emotional expressions more quickly, although the addition of emotion labels did not increase their speed of recognition.

The children with Down syndrome did not differ significantly from the other groups in their ability to label basic emotions, or in their speed and accuracy of emotion matching overall. However, in relation to specific emotions, they were significantly less accurate than the typically developing children in the recognition of fear. Accuracy scores of children with Down syndrome for fear were not significantly different from chance. These fear recognition difficulties were not obviously linguistic in nature, as they were still evident when emotion labels were absent from task instructions. Recognition of fear was facilitated neither by the use of emotion labels nor by the use of exaggerated expressions.

Children with non-specific intellectual disability were significantly less accurate than the typically developing children in emotion recognition in general, though in contrast, significantly more accurate in the Benton face recognition task. This latter finding perhaps points to the role of experience in face recognition (though for recent discussion see McKone, Crookes, Jeffery & Dilks, 2012). Specifically, within emotion recognition they were significantly less accurate in the recognition of anger, again with recognition abilities not significantly different from chance. Indeed, participants across all groups found anger difficult to recognize. This may have been because the target and response anger stimuli were more dissimilar than in the case of the other emotions (a closed and an open-mouth expression of anger). In all three groups emotion recognition accuracy was correlated with mental age and vocabulary comprehension, but not with emotion labelling ability.

Other research studies have found greater evidence of difficulties in emotional understanding in Down syndrome (e.g. Kasari et al., 2001; Williams et al., 2005; Wishart et al., 2007). The finding here that emotion recognition in general was not an area of difficulty beyond what would be expected given their mental age, is very encouraging. Indeed, it was notable that the performance of the Down syndrome and the typically developing groups in this study were, overall, marked more by similarity than difference. This pattern of findings is

in concordance with findings from some previous studies (e.g. Channell et al., 2014; Pochon & Declerq, 2013). The reasons for the discrepancy in findings across different studies are unclear, but may relate to differences in participants, stimuli or tasks (Channell et al., 2014). For example, participants in the present study had higher mean language ability than those in previous studies with contrasting findings (though different language measures across studies makes comparison difficult), and the present study used different tasks and stimuli than in some previous studies (e.g. Kasari et al., 2001 used a puppet paradigm).

In relation to the current study it must be borne in mind that the three participant groups were matched on cognitive ability. Given that overall emotion matching scores were not yet at ceiling in the much younger typically developing children, differences in emotion recognition abilities might have been found had the children with Down syndrome been compared with peers of similar chronological age. As many children with Down syndrome now attend mainstream school, additional support in emotion recognition may therefore be required to facilitate social interaction with peers in their own age group. The results of the present study suggest that labelling emotions and using exaggerated emotional expressions may be helpful here, at least for some emotions.

Although emotion recognition in general was not found to be any more difficult for the children with Down syndrome than the two comparison groups, they were significantly less accurate than the typically developing children in the recognition of fearful expressions. This significant difference was found in three of the four conditions (labelled; non-labelled; exaggerated) and it approached significance in the fourth (veridical). This specific weakness in fear recognition ties in with findings from a number of previous studies (Kasari et al., 2001; Williams et al., 2005; Wishart & Pitcairn, 2000). However, it is worth noting that a difficulty in fear recognition was found only in comparison to the typically developing group, not in comparison to the non-specific intellectual disability group, suggesting that this

difficulty may not be strongly syndrome-specific (see also Turk & Cornish, 1998; Wishart et al., 2007). A larger scale study would be helpful in confirming this.

The fear recognition difficulty did not seem to stem from any linguistic problems in understanding and using the emotion label 'scared': participant groups did not differ significantly on verbal comprehension ability or in their ability to label a photograph of a fearful face. The children with Down syndrome moreover remained significantly less accurate than the typically developing children even in the condition in which instructions included no emotion label. This pattern of findings appears to contradict those of Pochon and Declercq (2013, 2014), who reported that the emotion recognition difficulties found in children with Down syndrome stem primarily from problems with emotion labels, rather than from a difficulty in recognizing facial expressions *per se*. However, emotion labels are more important in the recognition of some emotions than others (Widen & Russell, 2004) and it is possible that this apparent contradiction in findings stems from a difference between our own study and that of Pochon and Declercq in the extent to which analysis was conducted at the level of individual emotions. One further complication is that even in the absence of its use by the experimenter, children may use emotion labelling internally to assist them with emotion recognition tasks. This too would be worth investigating more fully in the future, given that self-produced labelling has been shown to enhance emotion perception in typical development (Lindquist et al., 2006).

The continuing difficulty in fear recognition, regardless of the presence or absence of a linguistic label, suggests that some children with Down syndrome have a perceptual difficulty in interpreting this specific facial expression. This may in turn relate to more basic face processing difficulties amongst this group. Vicari et al. (2000), for example, have noted that recognition of emotions such as fear and anger require the processing of both the upper and the lower parts of the face, while research by Carvajal, Fernández-Alcaraz, Rueda, & Sarrión

(2012) has shown that adults with Down syndrome may focus on the lower more than the upper half of the face when processing emotional expressions. However, the extent to which such findings, in the absence of significant parallel difficulties with anger, can explain fear recognition difficulties in Down syndrome is unclear.

In typical development, a developmental exploration of fear recognition at a neurological level has been shown to be informative (e.g. Guyer et al., 2008), with fear recognition linked to the amygdala (for review and a contrasting neural model of emotion recognition see Lindquist, Wager, Kober, Bliss-Moreau, & Barrett, 2012). While this merits closer consideration in Down syndrome, it is worth noting that although some studies have reported reduced amygdala volume in Down syndrome, this does not always remain after adjustment for overall brain volume, and in adults is complicated by the possible presence of Alzheimer's dementia (Aylward et al., 1999; Constable et al., 2010; Krasuki et al., 2002; White et al., 2003 – for a recent developmental neurological overview see Karmiloff-Smith et al., 2016). Further exploration of environmental influences on the development of fear recognition skills in Down syndrome should also be explored, for example investigating the role of the children's own experiences of displaying and observing this emotion. Bringing these various 'layers' of developmental pathways together in a causal model of socio-cognitive development might well prove informative in the future (see Cebula, Moore & Wishart, 2010; Moore & George, 2014).

As important as establishing the cause of fear recognition difficulties identified in laboratory-based studies is the need to establish whether this difficulty is observed in the everyday lives of children with Down syndrome and, if so, whether this influences their behavior or social interactions. Even if fear is difficult for some children with Down syndrome to recognize, it may be that this does not affect day-to-day interactions in any substantive way. This is not to suggest that recognition of fearful expressions is unimportant

(see e.g. Thurman & Mervis, 2013; Knieps, Walden & Baxter, 1994), but rather that if interventions to better support adaptive social functioning are to be identified, there is a need to understand more fully the impact of emotion recognition ability on the social experiences of individuals with intellectual disabilities (Zaja & Rojahn, 2008).

Although findings from the specific paradigm used here must be generalized with caution, they do suggest that in the early stages of any intervention to support the development of emotion recognition skills, it might be worth exploring whether individual children with Down syndrome do require particular support with recognition of fearful expressions. It may also be worth considering the use of exaggerated expressions (either in depicted or real life contexts) to help underpin identification of more subtle and complex emotions at a later stage in development. Whilst there is little direct evidence in the literature to support the use of exaggerated over veridical emotions in the learning of emotional expressions, there is some indirect support for this in studies of how caregivers interact with their infants in the early stages of learning about emotions. Caregivers typically exaggerate their facial expressions when interacting with infants (e.g. Stern, 1974), and in relation to positive emotions such as smiling, more intense expressions better capture the attention of infants (Kuchuk, Vibbert, & Bornstein, 1986). The use of cartoon/schematic emotions (which often accentuate the key features of expressions) is also already established in emotion recognition interventions for children with developmental disabilities (e.g. Silver and Oakes, 2001), suggesting that such approaches might merit evaluation with children with Down syndrome, including attention to how progress is made in recognizing more subtly-expressed emotion in everyday social situations. The findings from this study also suggest that the use of emotion labels might be similarly helpful in supporting emotion recognition. Research with typically developing children, however, suggests that exploring the embedding of these

labels in causal conversational contexts may be particularly productive in supporting the development of emotional understanding (Brown & Dunn, 1996; see Salmon et al., 2013).

In terms of facilitating emotion recognition development, the use of exaggerated emotions and emotion labels may not be equally facilitative for all emotions, however. Results from the present study indicated that the fear recognition ability of the children with Down syndrome - which was at chance level - did not improve under either of these conditions. This might suggest that approaches need to be individually tailored more closely to specific emotion and developmental stage in order to be effective.

In contrast to our earlier work (e.g. Williams et al., 2005; Wishart et al., 2007), the present study found that emotion recognition ability amongst children with Down syndrome was significantly correlated with broader aspects of cognitive and language development, such as performance mental age, verbal mental age, and vocabulary comprehension ability. The present finding suggests that emotion recognition ability does not necessarily unfold in isolation from other development domains. It is therefore important to consider whether strengthening domain general aspects of development, such as language and cognition, might also enhance emotion recognition skills (Rosenqvist, Lahti-Nuuttila, Laasonen, & Korkman, 2014, see also Happe & Frith, 2014). Supporting more general language development is a common intervention goal for children with Down syndrome (Fidler, Philofsky, & Hepburn, 2007), but might also provide some concomitant support for emotion recognition. Support of other core cognitive skills, such as verbal short-term memory, working memory, and visual selective attention, all known to be areas of difficulty for those with Down syndrome (e.g. Breckenridge, Braddick, Anker, Woodhouse & Atkinson, 2013; Brock & Jarrold, 2005; Cornish, Scerif & Karmiloff-Smith, 2007; Costanzo et al., 2013), and also linked to emotion recognition (Buitelaar, van der Wees, Swaab-Barnveld & van der Gaag, 1999; Matthersul et al., 2009; Rosenqvist et al., 2014), might also be beneficial. Given the role of one's own

emotional experiences, and that of close family members, on emotion recognition abilities (e.g. Kujawa et al., 2014; Loi, Vaidya & Paradiso, 2013; Whittington & Holland, 2011), taking into account the broader environmental context of the child may also be informative.

In all participant groups, general language measures (VMA and vocabulary comprehension) were correlated with emotion recognition ability, but the production of emotion labels was not. In contrast, Herba et al. (2008) found that typically developing children's labelling ability was significantly correlated with emotion recognition accuracy. However, their task involved defining emotion labels and label-to-emotion matching, rather than label production, as in our study. In the present study there is a complex pattern of relationships between emotion recognition and language: our finding that the use of emotion labels improved recognition accuracy, along with the correlations between the tasks and the language measures, supports the view that, language in general and emotion words more specifically, play a key role in emotion recognition (Barrett et al. 2007). Yet the lack of correlation between children's ability to recognize emotions and to label them emphasizes again that emotional understanding is not a unidimensional aspect of development (Widen, Pochedly, & Russell, 2015).

When considering the findings from this study, some inherent limitations need to be taken into account. As with so many studies in this field, sample size was relatively small and the age range of the Down syndrome and non-specific intellectual disability groups was quite broad. However, all three participant groups were closely matched, and relatively homogeneous, in terms of developmental ability. It also has to be noted that the use of video analysis to measure response speeds may have been somewhat less accurate than if the trials had been presented via touchscreen computer. However, our previous work with these participant groups has found that children at this developmental level sometimes touch a number of photographs before settling on their final answer, making the use of touchscreens

potentially problematic. In addition our study employed archetypal black and white static images of facial expressions as stimuli. Clearly, in everyday life, as well as being dynamic and in context, emotions can often be more subtle and ambiguous (Barrett, Lindquist & Gendron, 2007). It is acknowledged that the use of static images in the present study limits its ecological validity, but it did have the advantage of reducing the memory load for the participating children. The stimuli also had high proven inter-rater reliability and included precisely-measured exaggerated emotions. Further work to explore the ability of children with Down syndrome to recognize fearful expressions using more naturalistic stimuli is nevertheless clearly desirable. The recent findings of Channell et al. (2014) are informative here in suggesting that emotion recognition may present as less of a difficulty in tasks using colour and dynamic stimuli, and also in highlighting the need for research into the use of emotion knowledge in ‘real time’ social interactions. Use of more recent threshold approaches to measuring emotion discrimination (e.g. Rodger, Vizioli, Ouyang & Caldara, 2015) would also be helpful in providing a finer-grained understanding of emotion recognition in Down syndrome, though the suitability of such lengthy tasks for participants with intellectual disability has yet to be established.

In future studies it might also be helpful to explore fear recognition in Down syndrome across a wider age range. In typically developing adults there is a slight, but significant, decrease in the ability to recognize fearful expressions with age (Calder et al., 2003). The neurological changes associated with dementia have been found early in life in Down syndrome (for overviews see Karmiloff-Smith et al., 2016; Zigman & Lott, 2007), but it would be premature to associate such changes at a neurological level with a difficulty in fear recognition at a behavioral level in children and young adults: searching for developmental explanations of recognition difficulties drawing on environmental and/or neurological correlates of Down syndrome itself might be more appropriate. Few studies to date

encompass both adults and children and with only a few notable exceptions, such as Kasari et al. (2001) and Pochon and Declercq (2013, 2014), little work in this field has been longitudinal. It seems likely therefore that research across a wider age-span, with accompanying profiles on more global aspects of developmental and neurological functioning, could be helpful in furthering our understanding of how face processing and emotion recognition develop with age in Down syndrome, pinpointing strengths and weaknesses and better informing intervention strategies where appropriate.

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Table 1

Characteristics of mental age-matched groups

Variable	Group (N = 21 per group)									ANOVA values	
	Down syndrome			Non-specific intellectual disability			Typically developing				
	Mean	(SD)	Range	Mean	(SD)	Range	Mean	(SD)	Range	F (2, 60)	p value
CA	14.76	(25.3)	10.92 – 18.75	13.35	(35.3)	9.08 – 17.42	4.51	(9.4)	3.33 – 5.75	141.72	.000***
MA	4.27	(6.1)	3.75 – 5.75	4.56	(9.8)	3.08 – 5.92	4.68	(7.4)	3.58 – 5.50	2.15	.125
PMA	4.48	(7.0)	3.25 – 5.75	4.67	(10.2)	3.17 – 6.25	4.98	(9.04)	3.92 – 6.50	2.44	.096
VMA	4.07	(7.2)	3.42 – 5.75	4.48	(11.2)	3.00 – 6.00	4.41	(8.32)	3.00 – 5.75	1.74	.185
Vocabulary											
comprehension	5.26	(21.3)	2.75 – 8.00	5.83	(19.7)	2.83 – 8.17	5.42	(18.5)	2.00 – 7.58	0.66	.523
Benton Facial											
Recognition Test	14.0	(2.7)	9 - 19	16.1	(3.3)	11 - 22	13.7	(2.0)	11-17	4.74	.012*
N male/female	8/13			9/12			12/9			$\chi^2(2) = 1.66$	

* $p < .05$; *** $p < 0.001$

Note:

With the exception of the Benton Facial Recognition Test all test scores are reported as age equivalents in years and SDs in months.

Table 2

Emotion-matching task accuracy scores

Trials	Group (N = 21 per group)					
	Down syndrome		Non-specific intellectual disability		Typically developing	
	Mean	(SD)	Mean	(SD)	Mean	(SD)
veridical emotion	16.86	(4.17)	15.10	(5.00)	18.43	(4.31)
exaggerated emotion	17.48	(3.70)	15.81	(5.88)	19.43	(3.70)
non-labelled emotion	15.81	(4.47)	15.10	(5.20)	17.52	(4.85)
labelled emotion	18.52	(3.75)	15.81	(6.17)	20.33	(3.99)
Total score[†]	34.33	(7.59)	30.90 ^a	(10.70)	37.86 ^a	(7.84)

^a significant difference across groups, $p < .05$

[†] Total scores are not the sum of the four conditions, because the four conditions were not separately presented. Rather, the emotion presented in each trial was either veridical or exaggerated *and* either labelled or non-labelled.

Note:

Maximum score = 24 for each condition and 48 for total score. Score achievable by chance alone = 8 for each condition and 16 for total score.

Table 3

Emotion-matching task average response times (seconds) – all trials (correct and incorrect)

Trials	Group (N = 20 per group [†])					
	Down syndrome		Non-specific intellectual disability		Typically developing	
	Mean	(SD)	Mean	(SD)	Mean	(SD)
veridical emotion	2.93	(0.92)	3.18	(2.02)	3.95	(2.00)
exaggerated emotion	2.59	(0.78)	2.78	(1.82)	3.45	(1.68)
non-labelled emotion	2.69	(1.18)	3.05	(2.14)	3.50	(1.56)
labelled emotion	2.83	(0.81)	2.91	(1.99)	3.90	(2.64)
Mean (SD) response time	2.76	(0.83)	2.98	(1.90)	3.70	(1.82)

[†] Response times for three participants (one from each group) were omitted from analysis, as they were > 3SDs above the group mean. Groups did not differ significantly on mental age or vocabulary comprehension levels once these participants had been removed.

Table 4

Total accuracy scores for individual emotions (conditions collapsed)

	Group (N = 21 per group)					
	Down syndrome		Non-specific intellectual disability		Typically developing	
	Mean	(SD)	Mean	(SD)	Mean	(SD)
Happiness	7.29	(1.06)	6.38	(1.80)	7.24	(1.18)
Sadness	6.43	(1.69)	5.67	(2.69)	6.24	(1.67)
Anger	3.67	(2.33)	2.76 ^a	(1.97)	5.14 ^a	(2.56)
Surprise	6.62	(1.53)	6.00	(2.15)	6.67	(1.65)
Fear	3.71 ^b	(2.31)	4.52	(2.34)	5.62 ^b	(1.88)
Disgust	6.62	(1.69)	5.57	(2.42)	6.95	(1.63)

^a significant non-specific intellectual disability-typically developing group difference in anger recognition, $p < .01$;

^b significant Down syndrome-typically developing group difference in fear recognition, $p < .05$

Note: Maximum possible score = 8; score achievable by chance = 2.67.

Table 5

Correlations between emotion-matching score and assessment measures, and pre-task emotion label production

Variable	Emotion-matching task score		
	Group (N = 21 per group)		
	Down syndrome	Non-specific intellectual disability	Typically developing
CA	0.11	-0.36	0.47*
MA	0.54*	0.78**	0.53*
PMA	0.46*	0.75**	0.41
VMA	0.45*	0.67**	0.46*
Benton	0.44*	0.73**	0.17
Vocabulary comprehension	0.75**	0.60**	0.64**
Emotion label production	0.38	0.42	0.24

* $p < .05$; ** $p < .01$